

MODIS IMAGE REGISTRATION

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**Introduction:** The MODIS Science Data Support Team has begun a survey to identify the significant questions and issues associated with MODIS image-to-map registration (registering MODIS images to Ground Control Points (GCP)) for more precise earth location. In addition, image-to-image registration is being considered for the purpose of providing a good basis for examining changes in the recorded sensor data over time. A plan for MODIS image registration will be developed and circulated to the science team for comments and modification.

**Background:** Efforts to build an automatic image registration system for MODIS must take into account the lessons learned in the extensive work that has already been done with images from Landsat, AVHRR, and other systems. As a first step, discussions are being held with many persons who have experience in image registration. These include H.K. Ramapriyan (GSFC, Thematic Mapper (TM)), Ken Jones (JPL, MISR), Bill Clark (CSC, EOSAT, Landsat), and several people associated with the EROS Data Center (EDC) (R.J. Thompson, Lynn Olsen, John Boyd, Dan Steinwand, Glenn Kelly, Joy Hood, Chuck Wivell, Doug Hollaren, and Jeff Eidenshink). The discussions with EDC relate primarily to experiences with Advanced Very High Resolution Radiometer (AVHRR) image registration over the United States.

Journal articles, references, and other background information are also being collected.

**Basic Plan for MODIS Image Registration:** The basic plan for MODIS image registration is to provide improved image location information for each scene over land areas. This information would be included in the MODIS Level-1B data product.

Several steps would be involved in preparing for this task.

**Identify promising techniques and algorithms.** The Fast Fourier Transform (FFT) was applied successfully to Landsat 1, 2 and 3 images. Precise registration was achieved with edge detection methods on Landsat 4 and 5 data. A method which offers the best possibility of providing a fully automatic process (or nearly so) would be very desirable for use with MODIS images. Extensive cloud cover hinders successful registration. Partial missing data is also a problem for most algorithms. Data loss is frequently due to sun angle, haze, etc. The adopted technique, or algorithm, should provide for identification and work-around or

rejection of problem scenes without human intervention. The algorithm must be suitable for production processing.

Identify tasks involved in selecting a good set of GCPs. This will involve the identification of 100-meter to 500-meter feature types with well defined edges. Land-water interfaces are often unreliable because of movement. Existing sets of GCPs should be examined for their suitability in the MODIS application. Dependence on frequency bands, gain, radiance range, seasonal variations, atmospheric conditions, spatial resolution, etc. will influence the usefulness of different types of features. Geographical areas where additional work is needed should be identified.

Test various candidate algorithms using real data. Make test applications with AVHRR and/or MODIS Airborne Simulator (MAS) data.

Identify the computer resources required to do production image registration. The major part of MODIS Level-1 processing could be devoted to image registration. Any special (or unusual) hardware and/or software requirements must be identified at an early stage.

#### Challenging problems:

The consensus of the experts is that it will be a very challenging task to develop a reliable automatic system which will consistently do image registration at the 0.2 pixel level of accuracy for all seasons of the year, atmospheric conditions, etc.

Precise global image registration will most likely depend on the availability and proper use of an accurate global Digital Elevation Model (DEM).

Existing GCPs may not be suitable because of differences in resolution, frequency bands, etc. They are also not global. In many parts of the world, maps are not good enough for selecting 100-meter to 500-meter GCPs.

Dependence on coastlines may cause errors due to tides, etc.

GCPs may be sensitive to seasonal changes, etc..

No adequate atmospheric model exists.

**Questions:**

**Coverage:**

Is registration required globally or locally?

Is registration required on-demand or always?

**Type of registration:**

Is scene-to-scene registration required or is it required that images be registered to a map?

**Accuracy:**

What are the requirements?

Are the accuracy requirements for on-demand registration different from those for continuous registration?

Are the accuracy requirements for global registration different from those for local registration?

Are the accuracy requirements for image-to-image registration different from those for image-to-map registration?

What should be done in cases where the image registration process fails due to cloud cover, missing data, etc.?